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ASF SAR PROCESSING SYSTEM OVERVIEW

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ABSTRACT

The Alaska SAR Facility (ASF) situated at the. University of Alaska Fairbanks (UAF) is currently undergoing an extensive development effort to increase its capabilities in handling new sensors and in the areas of throughput, data handling, archive, and distribution [15]. The SAR Processing System (SPS) in particular will be much enhanced and will expand from the current single processor configuration to one that consists of three SAR processors in total. With the new SPS, the current processing capabilities for ERS-1 and JERS - 1 will remain Added will be processing capabilities for ERS-2 (late 1994) and RADARSAT (early 1995), Moreover, improvements in the areas of throughput, reliability, maintainability and operability will be achieved.

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INTRODUCTION

The Alaska SAR Facility (ASF) is located at Fairbanks, Alaska and is operated by the University of Alaska. Through co-operative agreements established with various domestic and foreign flight agencies like NASA (National Aeronautical and Space Administration), ESA (European Space Agency), and NASDA (National Space Development Agency of Japan), ASF has been serving as one of several data processing facilities wmtd-wide that collect, process, archive and distribute data received from earth observing satellites ERS-1 and JERS-1. Through similar arrangements made with ESA and CSA (Canadian Space Administration), ASP' has been tasked to support new additional sensors being planned for launch and operations in late 1994 (ERS-2) and early 1995 (RADARSAT) as wall,

To bc.tier handle the expected increase in data volume and to better serve its data user communities, the entire ASF is undergoing an major upgrade [1 S]. A block diagram of the revised ASF is shown in Figure 1. The SAR Processing System (SPS) of the ASF is tasked with providing the necessary SAR data processing functions to handle ERS-1, ERS-2, JERS-1, and RADARSAT. The S1'S was first commissioned in 1991, supporting ERS-1 with a single SAR processor called the ASP (Alaska SAR Processor) [13]. The ASP was later adapted in **1992** to accommodate JERS-1 as well [14]. The anticipated processing requirements from upcoming new satellites such as ERS-2 and RADARSAT point to a need for additional processors and a new S1'S, To provide continual support to data users, the new S1'S is required to maintain the existing data processing capabilities for ERS-1 and JERS-1, but at the same time, be able to handle new data types and volumes brought upon by ERS-2 and RADARSAT. In addition, the design of the new S1'S is to conform to newly adopted ASF standards in the areas of system architecture, inter-process communication, error handling, and user interface [1 5],

The following sections provide an overview of the new S1'S within ASF and describes each of the S1'S component systems: CP (Control Processor), RDS (Raw Data Scanner), ASP, SSP (ScanSAR Processor), and PP (Precision Processor). Included at-c brief discussions on the design requirements, implementation approach, anti expected system performance. It concludes with a brief report on the present status and immediate milestones.

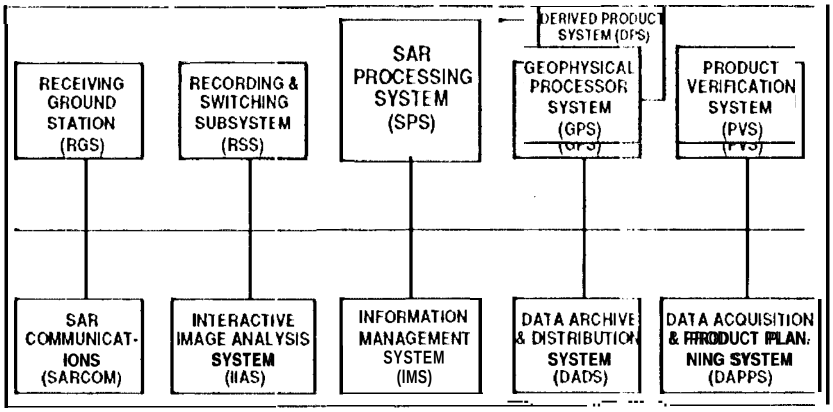

Figure 1,
ASF Block Diagram.

THE EXISTING SAR PROCESSING SYSTEM

The ASF block diagram as shown in Figure 2 shows the existing SPS in the current ASF system configuration. The SPS currently interfaces with the ACS (Archive & Catalog Subsystem) which handles processing requests and serves as an archive for data products, and to the RSS (Recording & Switching Sub-system) that contains high density tape drives for playback and recording of data.

The existing SPS consists of the ASP SAR processor and the Post processor that generates photographic products. The ASP is a custom designed and built hardware-basd SAR data processor. It is a second generation pipeline SAR processor to the ADSP (Advanced Digital SAR Processor) that was built in 1983 and later adapted for supporting the Magellan mission to Venus from 1990 to 1993 [7, 8,9]. The ASP implemented the fast FFT correlation algorithm in troth range and azimuth, It consists of 32 boards arranged in 5 cages that fits into a single rack. It operates at a clock rate of 10 MHz and is capable of up to 3.9 billion fixed-point operations per second. It has its own raw data deformatting and decoding capability and interfaces directly with the RSS, receiving its input raw data and offloading its output full-resolution image data directly onto high density digital tapes. Current processing throughput is on the order of **200100** x 100 km^2 image frames per day.

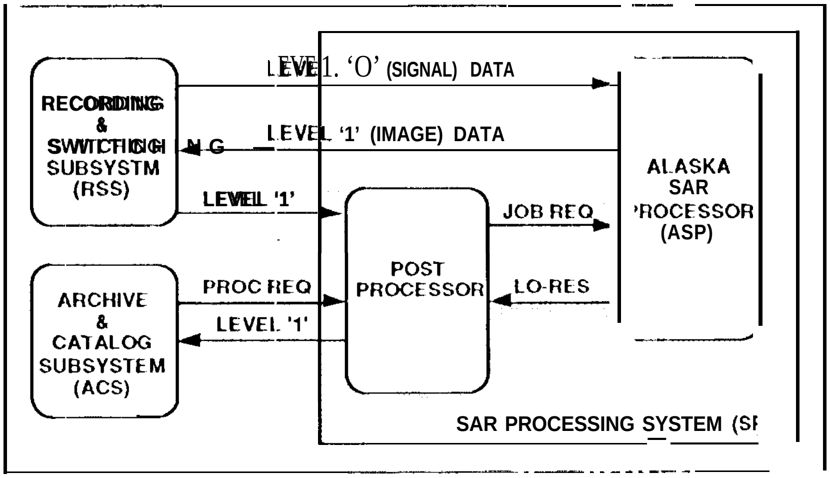

Figure 2.
Existing SPS Configuration

THE NEW SAR PROCESSING SYSTEM

New SPS Configuration

The new SPS block diagram is shown in Figure 3. It consists of five sub-systems:

- an upgraded version of the current Alaska SAR Processor (ASP) that also handles ERS-2 and RADARSAT data,
- a new ScanSAR Processor (SSP) for handling Scan SAR mode data from RADARSAT,
- a new Precision Processor (PP) for generating high precision image data products,
- a Raw Data Scanner (RDS) for extracting image frame information and determining raw data availability,
- a Control Processor (CP) for co-ordinating all processor controls and interfaces.

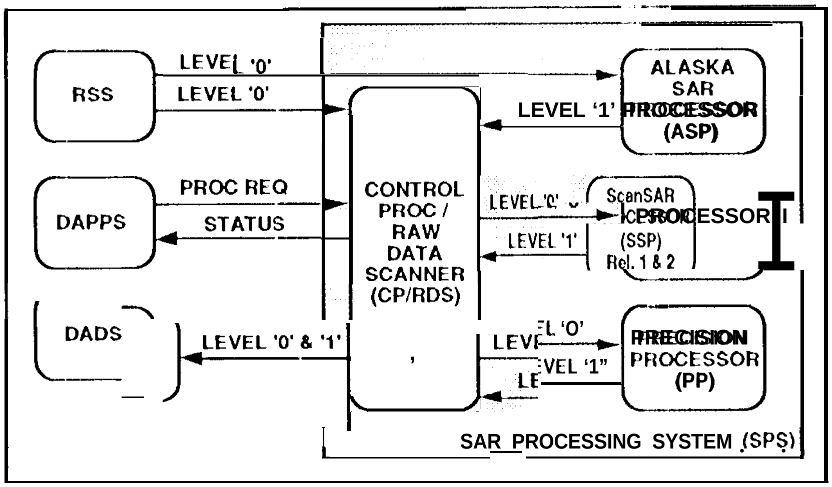

Figure 3.
New S1'S Block Diagram

Throughput

The processing throughput requirement of the new S1'S is largely shaped by science demand; and it now includes a 'reprocessing' capability that allows ASF to obviate the routine archive of level ' 1' image data products.

ASF is anticipated to receive a daily total of 200 minutes of data either directly via downlink from respective satellites or indirectly via shipment from foreign stations when ERS-1, ERS-2, JERS-1, and RADARSAT are all functional sometime in mid-1995 (see 'liable 1). Of this daily 2.00 minutes, a combined 40 minutes are estimated to come from ERS-1 and JERS-1, 40 minutes from ERS-2, and the remaining 120 minutes from RADARSAT. With RADARSAT capable of operating in either continuous mode or Scan SAR mode, it is estimated that about half of the expected 120 minutes of RADARSAT data received at ASF will be in Scan SAR mode.

The requirement on the upgraded ASP is to process daily 58 minutes of continuous mode data: a combined 10 minutes from ERS-1 and JERS-1, 28 from ERS-2, and 12 from RADARSAT. The remaining 8 minutes are split between 'quick-look' processing (using unrefined ephemeris information) and 'reprocessing' (using custom user-specified processing parameters).

The processing requirement on the SSP is to handle about half of the daily available Scan SAR data or about 30 minutes per day. In addition, a combined 4 minute. s of 'quick-look' processing and 'reprocessing' of ScanSAR data is planned.

The processing requirement on the PP is to process daily 5 minutes of continuous mode data: 1 minute from ERS-2, and 4 minutes from various continuous modes of RADARSAT.

To keep up with the available data at ASF, the RDS is required to 'scan' all 200 minutes of data received at ASF from all four satellites. This will allow an up-to-date data-base to be maintained at IMS (Information Management System) on the availability y of raw data.

Table 1. *SPS Processing Throughput Requirements.*

	E-1/J-1	E-2	RADARSAT		Q-L	Repr	TOTAL
			Cont	Scan			
ASP	10	28	12		3	5	58
SSP				60	3	5	68
PP		2	8				10
TOTAL	10	30	80		6	10	136
SCAN	40	40	120				200

NOTES: E: ERS; J: JERS; Q-J,: Quick-1ock; Repr: Reprocessing; Cent: Continuous mode; Scan: ScanSAR.

Data Products

The S1'S is designed to yield a variety of data products depending on data type:

Continuous mode SAR data: For cent inuous mode data, the *S1'S* is required to be capable of producing computer compatible signal data (CCSD) from raw signal data, singl c look complex image data, g round range ful]-resolution image data, 'quick--look' i m age data, and 'reprocessed' image data.

ScanSAR mode SAR data: For ScanSAR mode data, the SPS is requi red to produce geocoded ful I resolution i m age dat a, terrai n corrected full-resolution image data, 'quick-look' image data, and 'reprocessed' im age data,

SPS Implementation

SPS Implementation Approach: The implementation of the SPS follows an open system architecture approach and adheres to client-server as well as other project-wide inter-process communication and interface standards of the ASF [1 5]. The emphasis is on applying to the largest extent possible COTS hardware, software, standards, and technology. With minor exceptions in the AS]' where new custom hardware are unavoidable, all other sub-systems in the S1'S arc being implemented with commercial high performance workstations and mini-super computers running UNIX operating system. Compliance with POSIX (Portable Operating System Interface) and the X/Open Portability Guide is a requirement. And high-level programming languages such as ANSI C and FORTRAN arc selected for case of implementation and maintenance.

SPS Implementation Schedule: The implementat ion of the new SPS follows a phased approach due to fiscal and schedule constraints. The ASP upgrade task is targeted for completion in early 1995, in time for it to be ready for RADARSAT commissioning phase activities. The SS1' development is being split into two phases: a prototyping phase and a development phase. The first phase will result in early 1995 a Release 1 version of the SSP which will be used to help validate Scan SAR mode data acquisition during RADARSAT commissioning, This is then followed by a development phase hereby a Release 2 version of the SS1' will be ready for routine ScanSAR data processing operations in car] y 1996. The PP development is staged to follow that of the SS1' with a delivery date sometime i n late 1996, The CP/RDS development is spread out to cover through late 1996 with incremental deliveries that matches the deliveri es of the various SAR processor.

The Control Processor and Raw Data Scanner

Control Processor: The main functi on of the SPS Cent rol Processor (CP) is to provide overall control of all SAR processors within the SPS through a single operator interface. To enhance SPS operability, the CP also provides temporary data storage for all processors so that S1'S can operate without support from other ASF sub-systems such as DADS (Data Archive & Distribution System) for up to five days. The CP also hosts the image data quality control functions for SPS, allowing a centralized location to analyze raw data as wc]] as image data from various SAR processors. It also acts as a server interface to DAPPS (Data Acquisition & Production Planning System) under a client-server relationship, and provides interface with other external systems within ASF such as IMS and DADS.

Raw Data Scanner: The main function of the SPS Raw Data Scanner (RDS) is to deformat and decode raw signal data and auxiliary (including ephemeris and engineering) data that are embedded in the high-rate data stream down linked from each satellite. The decoded SAR signal data and auxiliary data are then fed to either the SSP or the PP for image generation. (Note that ASP has its own raw data decode and scanning capability.) A second function of the RDS is to provide an efficient 'scanning' capability for 'surveying' all available high-rate data to determine data availability and to capture 'image frame' recta data to be incorporated into a data-base at IMS to facilitate the product ordering process.

CP/RDS Implementation: A Silicon Graphics Challenge 1,/4 computer capable of upwards of 400 SpecInt 92. is being sought for the CP/RDS application, A Tri-Plex interface is included to provide RDS access to the high density tape drives at the RSS. In addition to handling all control and interface functions for the SPS, this system is expected to complete the daily 'scanning' of all 200 minutes of data plus supplying SSP and PP with 40 minutes of deformatted and decoded data within each 16-hour day. The delivery of the CP/RDS is being staged so that the appropriate CP/RDS capability is available to support each new processor that comes on-line.

The Alaska SAR Processor

ASP Upgrades: The existing Alaska SAR Processor (ASP) was designed to interface directly with the 1{SS tape system for data playback and recording. The ASP also performs its own data deformatting and decoding of ERS-1 and JERS-1 data. As part of the ASP upgrade, an addition of a RADARSAT deformatter board to the hardware correlator front-end enables the ASP to continue to function independently of the RDS for RADARSAT data input. The output full-resolution image data from the ASP is re-routed to go onto a disk system via a SCSI interface instead of going on tape via the RSS tape system. The Post Processor functions are removed from the ASP entirely and will be incorporation into the DADS. The ASP control functions arc being migrated from the existing MASSCOMP computer onto a more modern and efficient DEC-ALPHA workstation. This move is expected to enhance the interface between the ASP and the CP, and also address the longer-term maintainability issues with the MA SSCOMP. The re-routing of the full-resolution image data onto SCSI disk is expected to improve ASP system throughput as well as reliability.

ASP Upgrade Implementation: As described previousl y, the ASP upgrade involves both addition of custom hardware as well as upgrade of commercial hardware, The upgraded ASP is expected to process its dail y allotment of 58 minutes of continuous mode data within a 16-hour day. A 38% throughput margin is maintained to account of unscheduled system down time and processing errors. The expected avai lable date for the upgraded ASP is early 1995.

The ScanSAR Processor

The Scan SAR Processor (SSP) is developed for the soic purpose of generating wide swath images from data collected by RADARSAT under various Scan SAR operating modes. ScanSAR is similar in many ways to the burst-mode SAR used by Magellan for Venus mapping, Therefore, in terms of processing algorithm, a fair amount of inheritance is expected to come from the Magellan processors [7,8,9]. The implementation of the SSP is performed in two stages: a Release 1 version available in early 199S for validating Scan SAR data acquisition; followed by a Release 2 version in early 1996 for routine Scan SAR data processing, *SSP - Release 1 Implementation*: The objective of the Release 1 version of the SSP is to serve as a prototype, As such, it is expected to meet all SS1' requirements [1 -6] except for processing throughput. To satisfy the Scan SAR data validation need during the RADARSAT commissioning phase, it is anticipated that processing throughput on the order of about onc 500 X 500 km^2 image frame per day would be sufficient. A Silicon Graphics Challenge 1,/2 computer capable of a peak rate of 150 MFLOPs (1 SO x10^6 floating-point operations pcr second) is targeted for this application,

SSP - Release 2 *Implementation*: The Release 2 version of the SS1' will inherit and improve upon the algorithm and design of the Release 1 unit to meet operations throughput. A daily 34 minutes of Scan SAR data is targeted for this processor. It is estimated that a machine capable of sustained computation rate on the order of 500 MFLOPs is required to maintain a better than onc tenth real-time processing rate, Benchmark software runs are being conducted on various high performance workstations and mini-super computers, The hardware selection process is expected to be completed within the coming fcw months,

The Precision Processor

The main objective of the Precision Processor (P]') is demonstrate the feasibility of producing high preci sion image data products by eliminating to the largest extent possible processor-induced errors, Advent in latest algorithm technology has provided a class of so-called chirp-scaling algorithm [10,1 1,12] that showed potential for yielding high image fidelity in respect to radiometric, phase, and geometric accuracy. It is estimated such algorithm would require a sustained computation rate on the order of **500** MFLOPs to maintain a onc thirtieth real-time processing rate. With a throughput requirement of only 5 minutes of data pcr day, it is conceivable that the PP can be implemented on the same machine as the Release 2 of the SS1'. Algorithm simulation studies arc currently being conducted. And development of the P]' will follow that of the SS1' with completion targeted for late 1996.

SUMMARY & STATUS

in addition to being capable of handling the increased processing requirements brought on by ERS-2 and RADARSAT, the new S1'S presented here is capable of making future S1'S enhancements such as adding and upgrading new processors relatively straight forward. By conforming to popular industry standards and employing COTS components, the expandability and maintainability issues have been satisfactorily addressed. Design for the new ASF-SPS has gone through a functional design review in December 1993. Preliminary design of its component subsystems are being performed with appropriate design reviews targeted throughout the SlInlmcrof1994.

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